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# INTERIM REPORT ON PRIORITY OF STUDY OF ZONE 1 AND 2 LANDS - GOLDEN HORSESHOE - GEOLOGICAL CONSIDERATIONS

PREPARED BY:

GARTNER LEE ASSOCIATES LIMITED

APRIL 6, 1983

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April 6, 1983.

Ontario Waste Management Corporation,
2 Bloor Street West,
11th Floor,
Toronto, Ontario,
M4W 3E2.

Attention: Mr. E.H. Schmidt, P.Eng.
Project Director

Dear Sirs:

Re: Interim Report on Priority of Study of
Zone 1 and Zone 2 Lands - Golden Horseshoe

We are pleased to submit our interim report on the Priority of Study of Zone 1 and 2 lands within the Golden Horseshoe.

These lands embrace a large area. In order to accommodate this large area, we have placed a *priority of study* on these lands. In this way, we can concentrate our efforts on lands that appear to have a better likelihood of containing geological conditions suitable for the siting of facilities. This has resulted in three levels of priority -- Priority A, B and C for siting a landfill and two levels of priority for the physical/chemical treatment plant and incinerator shown as Priorities X and Y. This interim report describes the basis for choosing the priority of study for the various facilities.

A description of the hydrogeologic factors affecting facilities siting is contained in the companion Gartner Lee report "Hydrogeologic Considerations For Facility Siting".

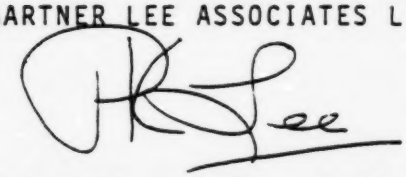
continued ..

Based on the present available level of information, we recommend that the Ontario Waste Management Corporation concentrate its search for a landfill or an integrated facility within the Priority A and Priority B lands depicted on Figure 2. Priority C lands can be evaluated at a later date in the event that acceptable sites cannot be found in the Priority A and B lands. For the physical/chemical treatment plant and incinerator, Priority X lands depicted on Figure 3 are preferred; however, Priority Y lands may also be considered depending on how much reliance OWMC wishes to place on the engineered containment features of the facilities.

We thank you for this opportunity to serve you.

Yours very truly,

GARTNER LEE ASSOCIATES LIMITED



P.K. Lee, M.A.Sc., P.Eng.
Consulting Engineering Geologist.

PKL:jcm

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# INTERIM REPORT ON PRIORITY OF STUDY OF ZONE 1 AND 2 LANDS - GOLDEN HORSESHOE -

## INTRODUCTION:

On January 13, 1983, the Ontario Waste Management Corporation released their Phase 2 report. This report announced the decision to concentrate the search for proposed facilities sites within the lands surrounding the western end of Lake Ontario, known as the "Golden Horseshoe". The search would be further focused on the Zone 1 and Zone 2 lands identified in the Corporation's Phase 1 report.

As a result of this decision, Gartner Lee Associates Limited was asked to further evaluate the geologic and hydrogeologic characteristics of these lands as they relate to the siting of facilities dealing with hazardous liquid industrial waste and other hazardous wastes.

This evaluation relates both to the siting of an integrated facility and to the siting of the separate components such as the landfill, and physical/chemical treatment plant. The reader is referred to a companion report titled "Hydrogeologic Considerations for Facility Siting" (Ontario Waste Management Corporation, April 1983)

for a more detailed description of the hydrogeologic factors affecting siting.

Zone 1 and 2 lands of the Golden Horseshoe identified in the Phase 1 report embrace a large area. In order to accommodate this large area, we have placed a *priority of study* on these lands. In this way the OWMC can focus efforts on lands that appear to have a better likelihood of containing substantial depths of uniform and fine textured overburden deposits.

The first task in assigning a *priority of study* to the Zone 1 and 2 lands of the Golden Horseshoe was to re-evaluate the information contained on the "Data Resource Sheets" (Ontario Waste Management Corporation, October 1982, Primary Environmental Information - Part I - Geological/ Hydrogeological Inventory) for each of the Hydrogeological Regions. This involved the following Regions, as referred to on the Phase 1 Hydrogeological Map.

Regions: 78, 79, 81, 82, 83, 86, 89, 96, 99, 100, 240, 241, 242, 243, 247, 248, 249.

The next task was to review the literature and our previous water well plot data in order to assess a priority of study on the lands. Supplementary well plots were made in selected areas.

This information was then re-evaluated using the Quaternary history of the areas. An understanding of the Quaternary

geologic materials and their history makes it possible to predict areas that may contain thick uniform silt-clay materials. This knowledge also makes it possible to identify areas containing variable and/or coarse grained materials. The informed use of water well information provides further evidence of the nature of the materials in the subsurface.

The seventeen Hydrogeologic Regions have been regrouped into eight areas for the following discussion (Figure 1). The boundaries, with minor adjustments, are the same as those presented in the Phase I Geological/Hydrogeological Report (Ontario Waste Management Corporation, October 1982 Primary Environmental Information, Geological/Hydrogeological Data Resource Sheets and Map).

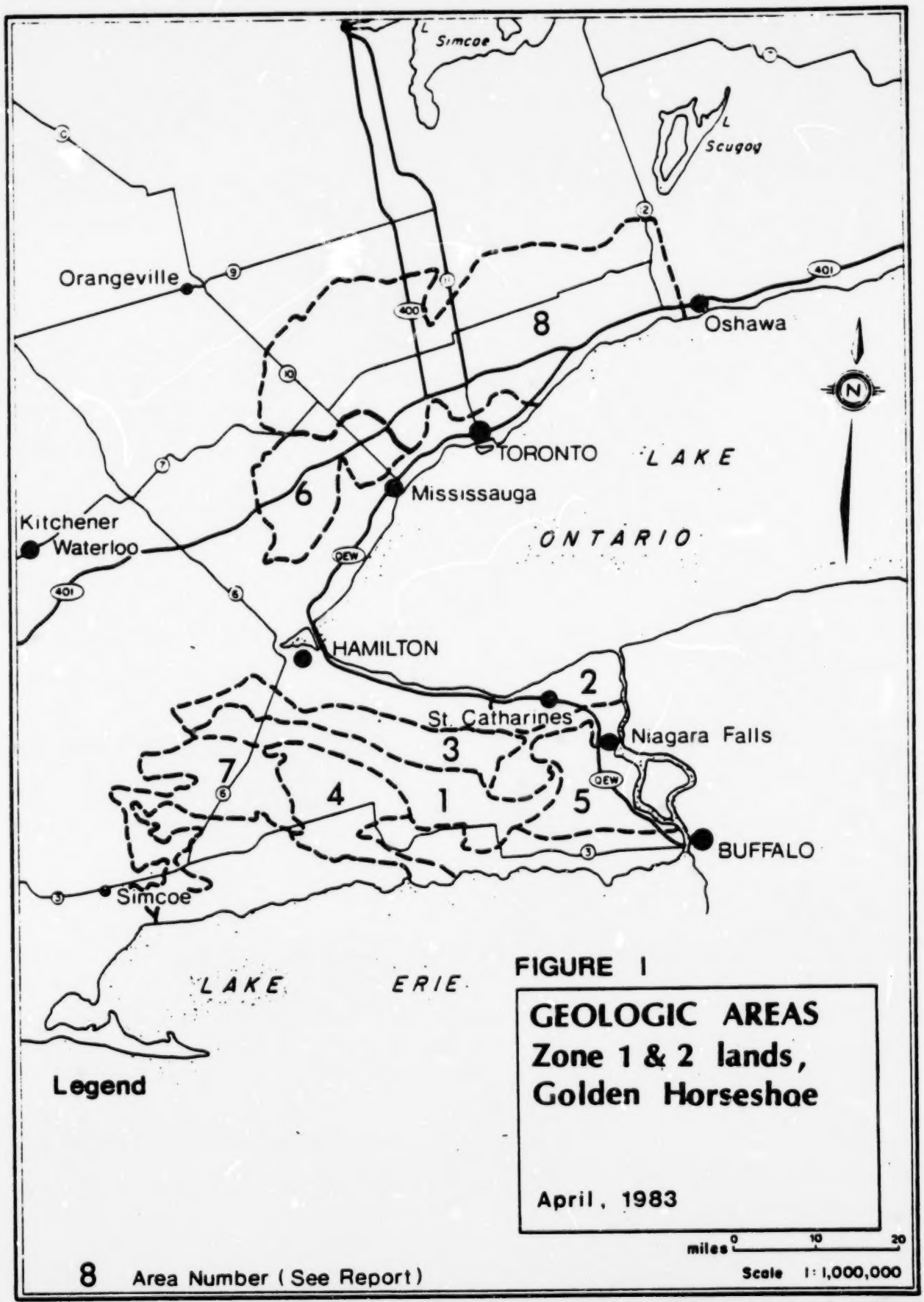


FIGURE 1

**GEOLOGIC AREAS**
**Zone 1 & 2 lands,**
**Golden Horseshoe**

April, 1983

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## DESCRIPTION OF LANDS:

*General:* North of Lake Ontario, the Quaternary geological units consist of a "stacked" sequence of several silt and sandy silt tills with interbedded sand. A clayey silt to sandy silt till is the most common unit at surface. The thickness of this till is quite variable and the underlying sand unit sometimes occurs at or near surface. In addition, glacial Lake Iroquois formed a beach shorebluff and associated surface deposit of sand and gravel, which is present from Toronto to Oshawa, parallel to the present Lake Ontario shoreline and several kilometres inland.

This pattern of variable thicknesses of till at surface overlying sand is particularly prevalent north and east of Toronto, in those lands shown as Area 8 (Figure 1). The tills in this area are generally more coarse grained than in the west, i.e. the sandy silt range of texture.

West of Toronto, in Area 6, in the Regional Municipality of Halton and part of Peel, the subsurface conditions change. The underlying bedrock becomes the red Queenston shale and the glacial till becomes progressively finer in texture (i.e. clayey silt) as one moves westward from Toronto. The occurrence of buried sands is not as prevalent but the depth to bedrock decreases, often 15 m or less from ground surface.

During the retreat of the last ice front, much of the land within the Niagara Peninsula was innundated by a large proglacial lake. It is this geological event and subsequent

related events which resulted in the deposition of thick silt-clay materials which exist in the Niagara Peninsula. Ontario Geological Survey work has identified three silt-clay units (two glaciolacustrine units and the Halton Till) of some depth overlying a sandy silt till (the Wentworth Till). There is a general tendency for the drift thickness to increase progressively from the Niagara Escarpment southward to the base of the Onondaga Escarpment.

Thick, uniform silt-clay materials occur in Area 1. Drift thicknesses here are commonly in the 15 m to 30 m range, especially in much of the area from Mount Hope to Welland-port-Wainfleet. Well logs indicate that "clay" comprises the bulk of the drift, and the materials are more uniform than in other parts of the Golden Horseshoe.

In Areas 2, 3, 4 and 5, there are occasional subsurface sands which may indicate a more variable stratigraphy. In some parts of these areas, bedrock comes close to surface.

In Area 7, in the southwestern part of the Niagara Peninsula, bedrock is very shallow in some places, and in other places the Quaternary materials contain a sandy till or sand horizons.

The following paragraphs are derived from the OWMC Phase I "Primary Environmental Information Geological/Hydrogeological Inventory" Data Resource Sheets and describe, in summary, the level of information that we currently have for each area.

Area 1: This area consists of silt-clay surficial deposits with very little surface relief. Feenstra (1981), 1975, 1974) has interpreted three silt-clay units overlying a coarse grained sandy silt till. The three silt-clay units -- an upper glaciolacustrine silt-clay, the Halton Till and a lower glaciolacustrine silt-clay -- have closely related geological origins and very similar grain size properties (Feenstra 1981). The upper unit is the most common surface unit, but the Halton Till occasionally occurs at surface. The lower sandy silt till is commonly found overlying the bedrock surface (Feenstra 1981, 1975, 1974). This sandy silt till is probably the same silt till unit which is exposed at surface in the Caledonia drumlin field (Areas 4 and 7). This lower till unit may be the source of ground water for some local wells. Feenstra (1981) also notes sand and/or gravel lenses within the lower glaciolacustrine unit at the Welland Canal.

Drift thickness mapping (Feenstra 1981, Vos 1969) and water well plots indicate a general tendency for thickness to increase progressively from the Niagara Escarpment southward to the base of the Onondaga Escarpment. Drift thicknesses are commonly in the 15 to 30 m range in much of the area from Mount Hope to Wellandport-Wainfleet area. Well logs indicate that "clay" (probably including both upper and lower glaciolacustrine units plus the Halton Till) represents the bulk of the drift in the region. "Sand" (sand and/or the lower sandy silt till) occurs locally between the "clay" and the underlying bedrock.

Area 2: A sharp increase in drift thickness and a change in the surficial materials is noted between the Grimsby

area and the St. Catharines sections of the Iroquois Lake Plain. This break occurs slightly west of Jordan Harbour. Area 2 typically has 10 to 30 m of drift containing two tills and overlying fine grained lacustrine sediments, sands and surface lake shoreline features (Feenstra 1981). Various authors have noted buried bedrock valleys in the area (summarized in Feenstra 1981). A number of buried distributary valleys from the St. Davids and Twelve Mile Creek buried bedrock valleys are known in the area. There is evidence of buried sand in two of these distributary valleys associated with the buried St. Davids Valley. Areas where there are no surface sands and no complexities within the drift sequences, are known in the region.

Area 3: This is an elongated area of the Haldimand clay plain stretching from Hamilton to the Pelham area. The area is typically a flat clay plain with little relief.

Mapping (Feenstra 1974, 1975, 1981) and water well data indicate substantial thicknesses of "clay" in the subsurface with a sandy silt till and/or sand and gravel overlying the bedrock surface. Feenstra (1981) notes four geological units in the region: an upper glaciolacustrine silt-clay, the Halton clayey silt till, a lower glaciolacustrine silt-clay and a basal layer of sandy silt till resting on bedrock. The upper three units constitute the "clay" of the well records and the lower sandy silt till may be noted as sand. This lower sandy silt till is probably the sandy silt till unit which occurs at surface in the Caledonia drumlin field (Areas 4 and 7).

A preliminary plot of water wells indicates some variability

in both the "clays" and the drift thickness. The western end of the region contains 20 to 25 m of drift on the average but some wells show several units and/or sand horizons. East of Hamilton bedrock is commonly close to the surface and outcrops are present in several creek valleys. Thicker drift containing sand lenses also occurs near the Fonthill kame. In general, the region contains variable thicknesses of "clay" materials.

Area 4: This area is a portion of the Haldimand clay plain bounded by the Onondaga Escarpment, the Welland River, the Caledonia drumlin field, and the Dunnville sand plain. The area is typically a nearly flat clay plain.

Feenstra (1975, 1981) notes four basic geological units in the region: an upper glaciolacustrine silt-clay, the Halton clayey silt till, a lower glaciolacustrine silt-clay, and a lowermost layer of sandy silt till resting on bedrock. The upper three units constitute the "clay" of the water well records and the lower sandy silt till may be noted as "sand" in the records. The detailed geology map indicates that this lowest sandy silt till outcrops at surface in eliptically shaped occurrences. These are, in fact, the tops of drumlins which are partially buried by the clay units in the area -- an extension of the Caledonia drumlin field (Areas 4 and 7). Drift thickness is commonly in the 15 m range with localized areas to 30 m. Wells located between known drumlins may indicate 20 to 25 m of "clay" with several metres of "sand" overlying bedrock.

Area 5: This area is the easternmost portion of the flat Haldimand clay plain. Feenstra (1981) indicates four geological units in the area: an upper glaciolacustrine silt-clay, the Halton clayey silt till, a lower glaciolacustrine silt-clay, and a basal layer of sandy silt till. The upper three units usually constitutes the "clay" of the well records.

Water well records for the area indicate 15 to 20 m of drift near Welland. Several wells in this area indicate locally shallow bedrock, till and/or gravel. Bedrock is present at 10 m or less in much of the Thorold and Stevensville area.

Area 6: This area is characterized by a gently sloping till plain. The till is the Halton clayey silt to silt till (Karrow 1963, Hewitt 1969) and the till plain is interrupted by several thin local sand deposits which were deposited on the till during the ponding of glacial meltwater in the area (the Peel Pondings). Bedrock outcrops of the Queenston Formation red shale occur in the Credit River Valley, along Oakville Creek and at the base of the Niagara Escarpment. Karrow (1963, p.46) indicates that "stratigraphic evidence of two till sheets is scarce, but a few sections in the area of the Cedar Springs reentrant reveal lenses of sandy till buried deeply under gravels that are capped by Halton Till...". There are occurrences of sand buried beneath the Halton Till to the north and east of the area, and a buried sand unit may occur commonly between the Halton Till and bedrock.

Published drift thickness plots of the area (Vos 1969,

Hewitt 1969) indicate a variable pattern in drift thickness. Shallow bedrock (<8 m) is noted in two areas near Milton -- to the south and to the east, and two areas north of Highway 401 -- northwest of Whaleys Corners and north of Mansewood. The remainder of the region exhibits 10 to 30 m of drift. Buried valleys are present near Drumquin, at Palermo and in the vicinity of Highway 401. This valley follows the highway route fairly closely and has two tributary valleys joining from the north. These originate in the Ashgrove and Mansewood areas.

Area 7: Area 7 is a long narrow area of generally silt-clay materials situated between an area of shallow bedrock (to the east) and a zone of abundant buried sand (to the west). Between Townsend Centre and Port Dover the area is characterized by moderate to thick (16 to 25 m) silt-clay over rock (Barnett 1978). The silt-clay thins towards the eastern side of the region and rock outcrop and thin drift areas are noted by Barnett along Nanticoke Creek, Black Creek, and along the Lake Erie shoreline. A plot of water wells generally confirms the pattern outlined by Barnett (1978), but sporadic buried sands and gravels have been noted in this part of the area. A scattering of wells show similar complexities along the western edge of the area and occasionally elsewhere. Surficial sands are also recorded in some of the area wells.

The northern part of this area contains the Caledonia drumlin field, which is centered on Oneida Township, between the towns of Caledonia and Hagersville. The area consists of a flat clay plain with a number of drumlins projecting through the clay. Feenstra (1974) indicates the till in

the drumlins is a sandy silt till. The drumlins "protrude through a cover of glaciolacustrine clay and silt." A scan of water well records indicates variable subsurface conditions. Drift thicknesses generally range between 10 and 20 m in the northern part but thin drift (ranging to outcrop) is expected to the south. Although many of the wells indicate simply clay over limestone, a significant number of wells (10 to 20%) note buried "hardpan" and/or "gravel" beneath the "clay". These data would suggest a limestone plain with an overlying sandy silt till unit of variable thickness, which in turn is overlain by glaciolacustrine silts and clays. The silts and clays may reach 20 m in thickness in some areas and occasionally contain sand lenses.

Area 8: The surface materials are mainly silt tills in Area 8 and the subsurface is known to contain several other silt till units which are commonly separated by units of sand. The surface slopes from the flanks of the Oak Ridges Moraine southward toward Lake Ontario. Most of the area was covered briefly by proglacial lake pondings which bevelled the till surface. The pondings left surface veneers (to 8 m thick) of fine sand, silt and clay in some areas -- notably adjacent to East Don River and at Buttonville. Published maps (White 1975, Hewitt 1969, and Sharpe 1980) indicate the surface tills may be one or more of the Wildfield, Halton, Leaside or Wentworth Tills -- they range from clayey silt to sandy silt in composition. Hewitt (1969) has mapped a number of occurrences of kame sands and gravels in the area. These are surface occurrences of the upper inter-till sand unit. "Hills, which resemble drumlins, are sometimes formed where the ice overrides a moulin kame hill of sand and

gravel." (Hewitt 1969, p.7). He indicates that this condition is common in the area and that the till ranges from 1 to 33 m in thickness overlying the sand. A sandy silt till has been noted beneath the kame sand unit in several pits in the region (Hewitt 1969, Hewitt and Karrow 1963). Regional well plots and geological cross sections (Sharpe 1980) indicate that buried inter-till sand bodies are common throughout the region between the several till units.

Drift thicknesses vary greatly -- there are indications of several major buried bedrock valleys. The bedrock is generally buried by 30 m or more of drift (varying up to 100 m or more in a major buried valley).

## PRIORITY OF STUDY - LANDFILL:

*General:* The nature of the hydrogeological setting (i.e. the physical characteristics of the geologic materials, the stratigraphic relationships of the various geologic materials, their thickness and continuity) are of importance when siting a landfill. Consideration should be given to assessing areas underlain by the deepest and most uniform silt-clay deposits first. For the purposes of siting a secure landfill, it is best to have at least 10 m of silt-clay to provide the necessary isolation from underlying units. Increasing assurance of isolation is afforded with greater thicknesses and predictability.

These two considerations may be applied to the geology of the eight areas on Figure 1 to yield a *Priority of Study for Landfill.* The following passages note the geological factors discussed previously that would bear on such a priorization of lands. The priorities are presented on Figure 2.

*Area 1:* Available data indicate that thick deposits of silt-clay are present throughout this area. These materials appear consistent and are fine grained silt-clay soils. There is a high probability of finding a suitable location for a landfill facility in this geologic environment. This area has been designated as priority "A".

*Area 2:* The generally thick silt-clay materials in Area 2 indicate that there is a strong possibility of

**FIGURE 2**

**GEOLOGIC PRIORITIES OF STUDY FOR LANDFILL**

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locating sites suitable for landfill facilities development within the area. The isolation of these more favourable zones will require a substantial amount of investigation and the area therefore warrants a moderate or "B" priority of study rating.

*Area 3:* There are significant occurrences of buried sand, buried sandy silt till and shallow bedrock in Areas 3 although the general geologic pattern is one of substantial thicknesses of silt-clay. These occurrences serve to give the area a moderate or "B" study priority.

*Area 4:* The occurrence of pockets of thick, consistent silt-clay is probable within Area 4. However, these pockets may be limited in size and require considerable effort to locate. Area 4 has therefore been given a moderate or "B" priority of study.

*Area 5:* The generally thick "clays" in Area 5 are interrupted by zones of shallow bedrock and buried sand and sandy silt till. These complexities indicate that Area 5 should receive a moderate or "B" study priority.

*Area 6:* Buried sand and shallow bedrock pose constraints in Area 6. Thick silt-clay soils are present locally but these may be difficult to locate without considerable field work. Area 6 has been given a "B" or moderate study priority.

*Area 7:* Shallow bedrock, buried drumlins composed of sandy silt till and buried sand lenses and zones render Area 7 relatively complex when compared with Areas 1 through 6. The likelihood of locating land suitable for landfill facilities development is substantially less than other areas and it has therefore been given study priority "C".

*Area 8:* The widespread occurrence of buried sand at several levels within the drift sequence renders Area 8 the least likely of the eight areas for the location of a landfill facility site. A considerable amount of effort will be required to isolate potential sites within Area 8. Area 8 has been designated as priority "C".

## PRIORITY OF STUDY - PHYSICAL/CHEMICAL PLANT AND INCINERATOR:

The same general principals which pertain to selecting a landfill site apply to selecting a site for a physical/chemical site or incinerator. The nature of the hydrogeological setting (i.e. physical characteristics of the geologic materials, the stratigraphic relationships of the various geologic materials, their thickness and continuity) will be of importance. It is assumed that there will be no burial of chemical substances at a physical/chemical plant or incinerator site and these facilities will likely have a finite life; therefore, it may be possible to site a treatment facility in areas containing lesser thicknesses of silt-clay materials. All areas of the Golden Horseshoe underlain by silt-clay materials may be considered for siting the incinerator and physical/chemical treatment facilities.

The eight areas have been re-assessed and study priorities X and Y have been assigned to the areas (Figure 3).

*Areas 1 through 5:* Areas 1 through 5 all contain moderate to thick deposits of silt-clay soils. There are local occurrences of bedrock near-surface and there are locally significant zones of buried sand and/or coarser grained tills. In general there is a high possibility of locating a physical/chemical plant or incinerator site within these areas and therefore an "X" priority of study rating has been assigned.

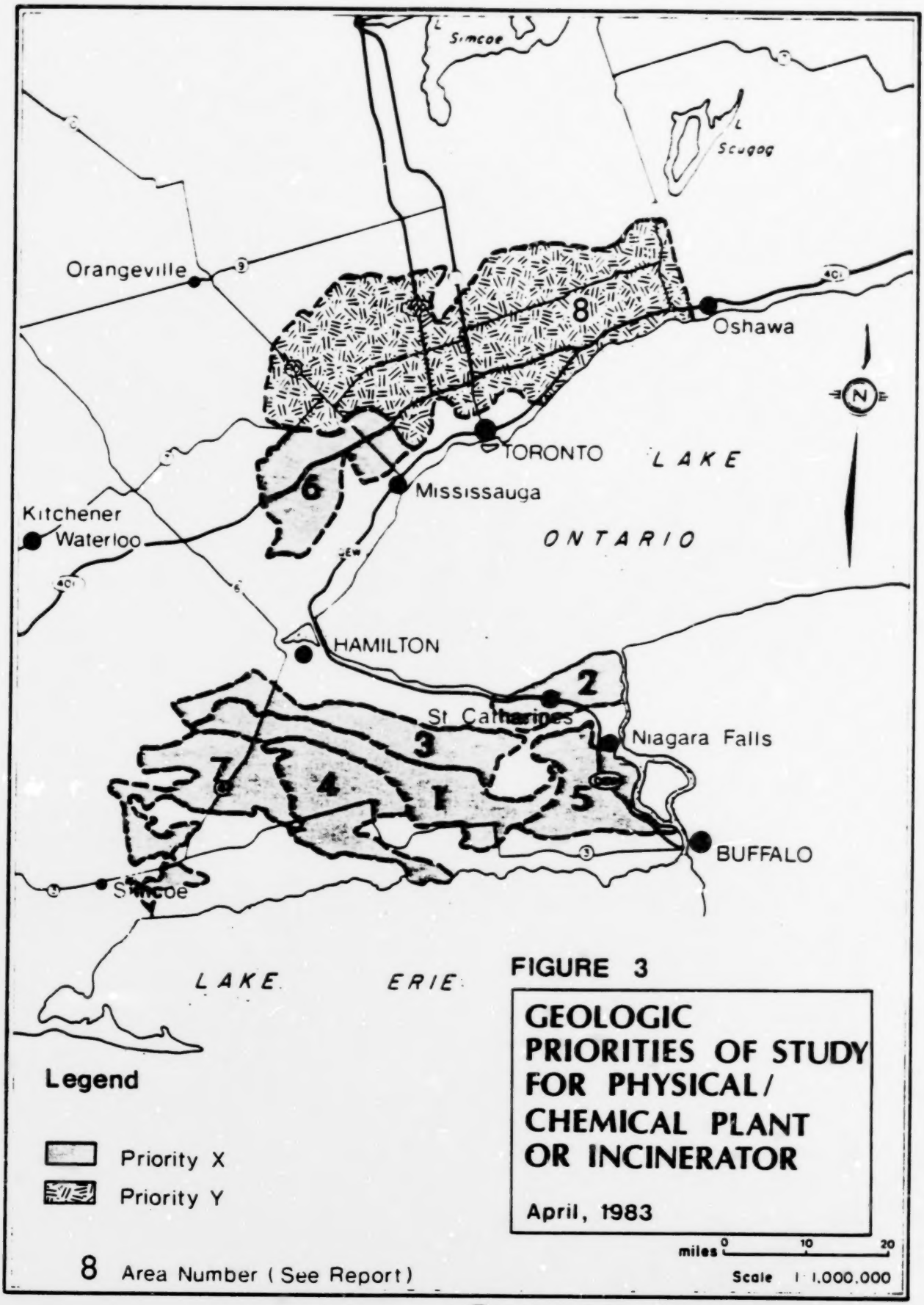


**FIGURE 3**

**GEOLOGIC PRIORITIES OF STUDY FOR PHYSICAL/ CHEMICAL PLANT OR INCINERATOR**

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*Area 6:* Much of Area 6 is covered by clayey silt till. There are zones of shallow bedrock and/or buried sand but there is a possibility of locating a physical/chemical plant or incinerator site in Area 6. It has therefore been assigned an "X" priority of study.

*Area 7:* Area 7 contains substantial silt-clay at surface. Local occurrences of shallow bedrock, buried sand and coarse-grained till will pose restrictions but there is a possibility of locating a physical/chemical plant or incinerator site. Area 7 has an "X" priority of study rating.

*Area 8:* The geology of Area 8 is substantially different from that of Areas 1 through 7. The dominant pattern is one of several silt to sandy silt tills separated by sand bodies of variable, and occasionally substantial, thickness. Shallow surface patches of silt-clay lacustrine sediments are known and buried clay units may also exist. Portions of Area 8 may contain no buried sand and/or sandy tills but considerable effort would be involved in establishing these zones and there is no assurance that a physical/chemical plant or incinerator site may be found. Area 8 is designated as having a lower, priority "Y", study rating.

## CONCLUSIONS AND RECOMMENDATIONS:

These conclusions and recommendations refer to the siting of a landfill or integrated facility and to the siting of a physical/chemical plant or incinerator site.

Based on the current level of geological information and our interpretation of the Quaternary geology, it is possible to group the Zone 1 and 2 lands of the Golden Horseshoe into levels of *Priority of Study*. The eight geological areas within the Golden Horseshoe have been assigned one of three priorities for landfill (A, B or C) and one of two priorities (X or Y) for a physical/chemical plant or incinerator.

The lands identified as Priority A have the best predicted geologic conditions for the siting of a landfill or integrated facility. Priority B lands are underlain by more variable geological strata or by bedrock at shallower depths. Priority C lands are underlain by complex and variable stratigraphy, including sand bodies and silt to sandy silt tills and the likelihood of finding sites is low.

The lands identified as Priority X have the least geologic restrictions for siting a physical/chemical plant or incinerator. Priority Y lands often have complex subsurface stratigraphy dominated by buried sand bodies and silt to sandy silt tills and there is less likelihood of finding a physical/chemical plant or incinerator site.

We recommend that the Ontario Waste Management Corporation concentrate its search for a landfill or an integrated facility site in the Priority A and Priority B lands. Priority C lands may be evaluated at a later date in the event that acceptable sites cannot be found in the Priority A and B lands. We further recommend that the Corporation concentrate its search for a physical/chemical plant and incinerator in Priority X lands. Priority Y lands may be evaluated at a later date if acceptable sites cannot be found in Priority X lands.

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QUALITY

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